REMARKS

This application is a continuation of parent application No. 10/175,149. In this amendment, claims 1 - 11 of the application as filed have been replaced by new claims 12 - 31 which are believed to patentably distinguish the present invention over the references cited in the parent application.

New independent claim 12 describes an alloy consisting of Cu, P, Ni, and Sn. Among the references cited in the parent of the present application was Japanese Published Unexamined Patent Application No. 2001-334384 (referred to below as Japan '384), which discloses a Sn-Ni-Cu alloy which may also contain one or more of Ag, In, Zn, Sb, Ge, and P. That reference was published on December 4, 2001. The present application claims the priority under 35 USC 119 of Japanese Patent Application No. 2001-195903, filed on June 28, 2001. An accurate translation of the Japanese priority application is attached to show that the feature of a Sn-Cu-Ni-P alloy is disclosed in the priority application. Since the filing date of the priority application is prior to the date of Japan '384 as a reference, Japan '384 is not a valid reference against the present application. Claim 12 and claims 13 - 19 which depend from it are thus allowable.

New independent claim 20 describes an alloy consisting of Sn, Cu, P, and Ge. In the Official Action of May 19, 2003 in connection with the parent application, such a claim was rejected as obvious in light of US 2002/0051728 A1, referred to below as Sato. In essence, the Official Action rejected a Sn-Cu-P-Ge

alloy as obvious because Sato discloses a genus of alloy compositions which encompass such an alloy. Paragraph 9 of the Official Action cites In re Woodruff, Merck & Co., Inc. v. Biocraft Laboratories, Inc., and In re Susi for the proposition that the disclosure of a genus automatically renders a species falling into that genus obvious. However, these cases are controverted by the more recent case of In re Baird, 29 USPQ2d 1550, 1552 (Fed. Cir. 1994), which holds that the fact that a claimed substance may be encompassed by a disclosed generic formula does not by itself render that substance obvious. This is particularly the case when a generic formula encompasses a huge number of possibilities, as is the case with the words "at least one second additional element selected from the group consisting of Bi, Ge, Ni, P, Mn, Au, Pd, Pt, S, In, and Sb" in Sato. Thus, in order for the alloy recited in claim 20 to be obvious, there must be some specific suggestion in Sato to select the combination of alloying elements set forth in this claim from the huge number of possible combinations covered by the generic formula in Sato. Since there is no such suggestion, Sato cannot render this claim obvious. Claim 20 and claims 21 - 26 which depend from claim 20 are therefore allowable.

New claims 24 - 26 further patentably distinguish the present invention from Sato. Claim 24 describes a flow soldered joint formed by flow soldering a lead-free solder alloy as claimed in claim 20, and claims 25 - 26 describe a soldering method comprising forming a bath of molten solder of the lead-free solder alloy as claimed in claim 20 and contacting an object

to be soldered with the molten solder. The Official Action of May 19, 2003 acknowledged that Sato does not disclose using any of its solders in flow soldering. However, the Official Action concluded that it would have been obvious to have used the solder alloys taught in Sato for flow soldering in light of Gontier (U.S. Patent No. 4,858,816), which was relied upon as teaching the use of wave soldering with a Sn-based solder. In support of this conclusion, the Official Action cited In re Laverne and LaVerne, 108 USPQ 335 (CCPA, 1956) for the proposition that "a use of a new material in an old patented process in not invention". This proposition can only be described as an old saw (the adage dating, according to page 338 of Laverne, back to 1884), and it does not represent the current state of the law. It states a per se rule instead of relying on objective evidence, and it ignores the requirement that the prior art or the knowledge generally available to one skilled in the art provide some objective teaching that would lead a person skilled in the art to combine the relevant teachings of the references. In re Fine, 5 USPQ2d 1596, 1598 (Fed. Cir. 1988). Gontier relates to a tin soldering machine for performing wave soldering. It does not teach any particular solder composition, and nowhere does it suggest that wave soldering is applicable to every type of solder, let alone to the solder compositions for solder balls set forth in Sato. Sato mentions nothing about wave soldering, and its alloy compositions are described only with respect to their use as solder balls. There is nothing in Sato to suggest to a person skilled in the art the use of the solder compositions of

Sato for any purpose except as solder balls, and all the benefits of the alloy compositions are tied to their use as solder balls.

Thus, as neither Sato nor Gontier provides any motivation to a person skilled in the art to modify Sato as proposed in the Official Action of May 19, 2003, the proposed modification is not reasonable. Accordingly, claims 24 - 26 are allowable over this proposed combination of references.

New independent claim 27 describes an alloy consisting of Sn, Cu, Ag, P, and Ge. In the Official Action of May 19, 2003, such a claim was rejected as obvious in light of Sato for the same reasons discussed above with respect to new claim 20, i.e., that Sato discloses a genus which encompasses a Sn-Cu-Ag-P-Ge alloy. However, as is the case with respect to new claim 20, Sato does not disclose or suggest this specific alloy, and it does not provide a person skilled in the art any motivation to select a Sn-Cu-Ag-P-Ge alloy from the more than one 1000 possible combinations of alloying elements which it discloses. As discussed above with respect to claim 20, the cases cited in paragraph 9 of the prior Official Action for the proposition that the disclosure of a genus renders any species falling within that genus prima facie obvious are outdated and controverted by In re Baird. Since Sato does not contain any specific suggestion for a person skilled in the art to select a Sn-Cu-Ag-P-Ge alloy from the huge number of possible combinations of alloying elements which it discloses, Sato cannot render claim 27 obvious. Claim 27 and claims 28 - 31 which depend from it are therefore allowable.

Like claims 24 - 26, claims 29 - 31 further patentably distinguish the present invention from Sato by describing a flow soldered joint formed by flow soldering a lead-free solder alloy as claimed in claim 27, or a soldering method comprising forming a bath of molten solder of the lead-free solder alloy as claimed in claim 27 and contacting an object to be soldered with the molten solder. As set forth above with respect to claims 24 - 26, there is no suggestion in Sato of using the solder alloys disclosed therein for any purpose except as solder balls, and thus no motivation to modify Sato to employ the solder alloys for flow soldering. Claims 29 - 31 are therefore allowable.

In light of the foregoing remarks, it is believed that the present application is in condition for allowance. Favorable consideration is respectfully requested.

Respectfully submitted,

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Attachment
Accurate translation of Japanese Patent Application No. 2001-195903

Translation of Japanese Patent Application No. 2001-195903

[Name of Document] Specification

[Title of the Invention] Lead-Free Solder Alloy

[Claims]

[Claim 1]

A lead free solder alloy characterized by comprising 0.1 - 3 mass percent of Cu, 0.001 - 0.1 mass percent of P, and a remainder of Sn.

[Claim 2]

A lead free solder alloy characterized by comprising 0.1 - 3 mass percent of Cu, 0.001 - 0.1 mass percent of P, 0.001 - 0.1 mass percent of Ge, and a remainder of Sn.

[Claim 3]

The lead free solder alloy of claim 1 or claim 2 to which a strength improving element is added.

[Claim 4]

A lead free solder alloy as claimed in claim 3 containing Ag and/or Sb in a total amount of at most 4 mass percent as the strength improving element.

[Claim 5]

A lead free solder alloy as claimed in claim 3 containing at least one element selected from the group of Ni, Co, Fe, Mn, Cr, and Mo in a total amount of at most 0.5 mass percent as the strength improving element.

[Claim 6]

A lead free solder alloy as claimed in claim 1, 2, or 5 wherein the solder alloy further includes a melting point lowering element.

[Claim 7]

A lead free solder alloy as claimed in claim 6 containing at least one of Bi, In, and Zn in a total amount of at most 5 mass percent as the melting point lowering element.

[Detailed Explanation of the Invention]

[0001]

Technical Field to Which the Invention Belongs

This invention relates to a solder alloy which does not employ lead. In particular, it relates to a solder alloy having excellent solderability when used for soldering electronic parts to a printed circuit board.

[0002]

[Prior Art]

Consumer electrical equipment such as televisions, videos, refrigerators, and air conditioners and electrical equipment such

as personal computers, printers and other office equipment which are used at home or in industries contain printed circuit boards. Printed circuit boards employ a large number of electronic parts, and soldering is employed to melt the electronic parts on the printed circuit boards.

[0003]

Taking into consideration workability with respect to electronic parts and printed circuit boards, presently used solders are Sn-Pb solders which have a low operating temperature and good solderabilty and have a long record of use. In particular, a Sn 63 mass %-Pb solder has a narrow melting point range near the eutectic among Sn-Pb solders, so it is widely used as an Sn-Pb eutectic solder. At the eutectic, the solder does not exhibit a melting point range, so after melting it immediately solidifies. During soldering, if the length of time from when solder melts until it solidifies is long, it becomes easy for cracks to form due to vibrations from the conveyer during transport of the printed circuit board or vibrations imparted during handling, so with a solder near the eutectic, this influence is small, and highly reliable soldering is carried out.

[0004]

In general, when electronic equipment breaks or becomes old and its function becomes inadequate, it is disposed of by being thrown out. Such electronic equipment includes ones having

plastic cases, ones having a metal chassis, and ones having synthetic resins and metal conductors mixed with each other as in synthetic resin printed circuit boards. Therefore, they are not incinerated but instead are cut up and buried underground as stable industrial waste.

However, in recent years, electronic equipment which has been buried underground has become a problem. Namely, due to much use of fossil fuels, sulfur oxides and nitrogen oxides are discharged in large amounts into the atmosphere, and acid rain is generated when rain passes through the atmosphere which has become acidified. The acid rain permeates into the ground, and it dissolves out lead and other harmful metals from the buried electronic equipment and pollutes underground water, and it is worried that if this underground water is drunk for long periods there is the fear of the occurrence of lead poisoning, so solder which does not contain lead has been desired.

[0005]

Lead free solders which have been developed up to now have Sn as a main component to which metals such as Cu, Ag, Bi, and Zn are added. Typical compositions of lead free solders are binary alloys such as Sn-0.7 mass percent Cu, Sn-3.5 mass percent Ag, Sn-58 mass percent Bi, and Sn-9 mass percent Zn. Depending upon the use, additional metal elements are combined to obtain a ternary alloy, or a larger number of alloying elements may be employed in accordance with the use.

[0006]

Each of these lead free alloys has its own problems. For example, with a Sn-Zn type solder such as Sn-9 mass percent Zn, Zn is an element which oxidizes extremely easily, so a thick oxide film readily forms, so if soldering is carried out in the air, wettability at the time of soldering is poor. In addition, when carrying out reflow soldering, a large amount of dross is formed, so there are large problems with respect to its practical application. With a Sn-Bi type solder such as Sn-58 mass percent Bi, the formation of dross during reflow soldering is not a large problem, but by adding Bi to a lead free solder, the properties of the solder reflect the poor ductility of Bi, so it has poor mechanical strength, and there is concern of a decrease in the reliability of soldered joint portions. In particular, there is a strong tendency for the mechanical strength to decrease as the amount of Bi increases.

[0007]

At present, the lead free solders which are considered most practical are Sn-Cu types such as Sn-0.7 mass percent Cu, Sn-Ag types such as Sn-3.5 mass percent Ag, and Sn-Ag-Cu types in which a small amount of Cu is added to a Sn-Ag type. However, while Sn-Cu types such as Sn-0.7 mass percent Cu are inexpensive, they have poor wettability at the time of soldering. On the other hand, with Sn-Ag types such as Sn-3.5 mass percent Ag or Sn-Ag-Cu types in which a small amount of Cu is added to a Sn-Ag type, the wettability at the time of soldering is relatively good. The

mechanical strength of Sn-Ag types and Sn-Ag-Cu types is the same or better than that of Sn-Pb types, so among lead free solders, they are preferred from the standpoint of properties. However, they contain expensive Ag, so their cost is high, but if the Ag content is decreased in order to reduce costs, the wettability and the alloy strength of the solder become inferior.

[0008]

[Problem Which the Invention is to Solve]

When mounting electronic parts on a printed circuit board for electronic equipment, the solder alloy to be employed is selected taking into consideration operability with respect to the electronic parts and the printed circuit board. When soldering is carried out, if the wettability of solder is poor, defects such as unsoldered portions, bridges, and voids end up occurring.

As described above, a Sn-Cu type which is thought to be a practical alloy composition for a lead free solder has a unit cost close to that of Sn-Pb types, so it is preferred, but unfortunately it has poor wettability as the time of soldering.

This invention provides a solder alloy which improves the wettability of Sn-Cu type lead free solders which typically have poor wettability.

[0009]

[Means for Solving the Problem]

The present inventors performed energetic investigations with respect to improving the solderabilty of a Sn-Cu type lead free solder. As a result, they found that addition of P to a Sn-Cu type lead free solder improves wettability at the time of soldering, and completed the present invention. This effect is obtained not only with addition of P by itself, but wettability at the time of soldering is further increased by the combined addition of P and Ge.

[0010]

This invention is a lead free solder alloy characterized by comprising 0.1-3 mass percent of Cu, 0.001 - 0.1 mass percent of P, and a remainder of Sn. It is also a lead free solder alloy characterized by comprising 0.1 - 3 mass percent of Cu, 0.001 - 0.1 mass percent of P, 0.001 - 0.1 mass percent of Ge, and a remainder of Sn.

[0011]

The presence of Cu in a Sn - Cu type lead free alloy has the effect of increasing the mechanical strength of the solder. In the present invention, if the Cu content is smaller than 0.1 mass percent, it has no effect on the mechanical strength of the solder, and if it is larger than 3 mass percent, it increases the melting temperature of the solder, it reduces wettability, and dross is produced at the time of melting of the solder, and this causes problems during soldering operation.

[0012]

In the present invention, if the added amount of P is smaller than 0.001 mass percent, there is no effect on the wettability of solder, and if it is larger than 0.1 mass percent, the viscosity of solder at the molten solder surface increases, the fluidity of the solder is impeded, and this causes problems in soldering operation. This is manifested by defects such as bridges at the time of soldering with molten solder.

[0013]

Wettability is further improved by adding Ge in addition to P. In the present invention, if the added amount of Ge is smaller than 0.001 mass percent, there is no effect on the wettability of the solder, and if it is larger than 0.1 mass percent, in the same manner as with P, it increases the viscosity of solder at the surface of molten solder, it obstructs the fluidity of solder, and it causes problems during soldering operation.

[0014]

If P and Ge are added to molten solder, these elements are thinly dispersed on the surface of the molten solder, and at the time of soldering, their oxides shield the surface of molten solder and prevent contact with the atmosphere, and they prevent the oxidation of the molten solder at a high temperature. At this time, the oxides of P readily sublimate at the temperature of the molten solder, but the oxides of Ge remain for a long time

on the surface of the molten solder, so if the added amount of Ge is large, soldering operations are impeded, and it becomes easy for defects to occur such as unsoldered portions. Therefore, it is necessary for the added amount of Ge to be at most 0.1 mass percent.

[0015]

In the present invention, the addition of P or the combined addition of P and Ge to a Sn-Cu type lead free solder has the effect of improving wettability, but it does not increase the mechanical strength of the solder alloy. The mechanical strength of a Sn-Cu type lead free solder alloy is of a level inferior to that of a Sn-Ag or Sn-Ag-Cu type lead free solder. This mechanical strength is not improved by the addition of P or P and Ge. In cases in which mechanical strength is required, it is necessary to add an element which improves mechanical strength. Ag, Sb, Ni, Co, Fe, Mn, Cr, Mo, and the like are effective as elements for improving the mechanical strength of a Sn-Cu type lead free solder. Each of these elements forms a solid solution with Sn, or it forms an intermetallic compound with Sn and improves mechanical strength, but if the added amount is large, the liquidus temperature increases, and the fluidity of solder is impeded. Therefore, the total amount of Ag and Sb is preferably at most 3 mass percent, and the total of Ni, Co, Fe, Mn, Cr, and Mo is preferably at most 0.5 mass percent.

[0016]

Sn-Cu types, Sn-Ag types, and Sn-Ag-Cu type solders which are seen as being promising among lead free solders have a high melting point compared to Sn-Pb type solders. Presently used electronic parts are designed using Sn-Pb type solders as a standard. When mounting electronic parts on a printed circuit board with a lead free solder, there is the possibility of operational problems occurring. In this case, by adding an element such as Bi, In, or Zn to a solder alloy according to the present invention, the melting point is decreased, and operational problems can be suppressed. Of these elements, Bi has poor ductility and is poor from the standpoint of mechanical strength, while In and Zn easily oxidize and easily form oxides, and they impede the solderability of the molten solder surface. Taking these facts into consideration, the total amount of Bi, In, and Zn which is added is preferably at most 5 mass percent.

[0017]

Examples and comparative examples are shown in Table 1.

[0018]

[TABLE 1]

	Composition (mass %)								Properties	
	Sn	Cu	P	Ge	Ag	Ni	Bi	Sb	Wettability Test *1	Bulk strength (MPa) *2
Example 1	rem	0.5	0.005	-	-	-	-	-	Excellent	32
Example 2	rem	0.7	0.01	-	-	-	-	-	Excellent	36
Example 3	rem	0.7	0.005	0.01	-	-	-	-	Excellent	36
Example 4	rem	0.5	0.005	-	0.3	-	-	-	Excellent	37
Example 6	rem	0.7	0.01	-	-	-	-	0.3	Good	36
Example 6	rem	0.7	0.003	0.01	-	0.05	-	-	Good	33
Example 7	rem	0.5	0.005	-	2	-	2	-	Excellent	73
Comparative Example 1	rem	0.7	-	-	-	-	-	-	Poor	31
Comparative Example 2	rem	0.7	-	-	0.1	-	-	-	Good	35
Comparative Example 3	rem	0.7	-	-	-	-	-	0.3	Excellent	31

[0019]

[Explanation of the Table]

Wettability Test: A Cu plate (0.3 millimeters thick x 10 millimeters wide x 30 millimeters long) was subjected to oxidizing treatment to form a test piece. A soldering flux was applied to the surface of the test piece, it was immersed in various types of solder maintained at 250°C, and a curve of wetting with respect to immersion time was obtained. Using the

so-called wetting balance method, the zero crossing time was measured, and the wettability for each type of solder alloy was compared. As a standard for judgment, ones with a zero crossing time of less than 2 seconds were excellent, those with a time of at least 2 seconds and less than 3 seconds were good, and those with a time of 3 seconds or above were poor.

Bulk Strength Test: A cast piece of solder was machined with a lathe to obtain a JIS Z 2201 Number 4 test piece. A tensile test was carried out using a universal tester with a crosshead speed corresponding to approximately 20 percent/min of the gauge length of each test piece, the maximum stress was found, and this was made the bulk strength.

[0020]

A lead free solder according to the present invention can be not only in the form of a rod or wire shaped solder, or it can be supplied to a product as shaped solders such as ribbons, pellets, discs, washers, or balls, or as powder.

[0021]

[Effects of the Invention]

A solder alloy according to the present invention has good wettability in spite of being a Sn-Cu type, so soldering operation can be stably carried out. In addition, it is a lead free solder which does not contain harmful Pb, so even when electronic equipment which is soldered using this alloy breaks or

becomes old and is disposed of by burial, lead components are not dissolved out by acid rain, so it is suitable with respect to environmental problems which have come to be seen as important in recent years.

[Name of Document] Abstract

[Abstract]

[Problem] Sn-Cu types which have thought to be a practical alloy composition as a lead free solder have a unit price close to Sn-Pb type solders, so they are advantageous, but unfortunately they have poor wettability at the time of soldering. This invention provides a solder alloy having improved solderability among Sn-Cu type lead free solders which generally have poor solderability.

[Means for Solving the Problem]

By adding P to a Sn-Cu type lead free solder, wettability at the time of soldering is improved. This effect is obtained not only when P is added alone, but wettability at the time of soldering is further improved by adding P together with Ge. However, if the added amount of P is less than 0.01 mass percent, there is no effect on wettability of the solder, and if it is larger than 0.1 mass percent, the viscosity of solder at the surface of molten solder increases, the fluidity of the solder is impeded, and this produces problems during soldering operation, so it is preferably in the amount of 0.001 mass percent - 0.1 mass percent.